PATENT ABSTRACTS OF JAPAN

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OTA JUNJI

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(54) ULTRASONIC WAVE TRANSMITTER-RECEIVER

(57)Abstract:

PROBLEM TO BE SOLVED: To make anisotropy of directivity characteristics in a horizontally installed direction and a vertically installed direction by making the range of transmission reception wave in the vertically installed direction (half of full angle) narrow in a small-sized ultrasonic wave transmitter-receiver.

SOLUTION: A hollow part 33 of a case 31 of this ultrasonic wave transmitter-receiver is open so as to be short in a horizontally installed direction and long in a

vertically installed direction. A thick part 32a is provided in the middle of a case bottom (bottom side of the hollow 33) 32, and a thin part 32b is provided to both sides in the horizontally installed direction. A piezoelectric vibrating element 35 is fixed to the thick part 32a.

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2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The ultrasonic transducer characterized by it having been comparatively long in the one direction, and having prepared the centrum which became comparatively short in the case object in another direction, having prepared the heavy-gage part and the thin-walled part in said pars basilaris ossis occipitalis in the ultrasonic transducer which has arranged the piezo-electric oscillating component dedicated in this centrum to the inside of said case object pars basilaris ossis occipitalis located in a centrum base in the cross section parallel to the pars basilaris ossis occipitalis of a case object, and having arranged said piezo-electric oscillating component to the heavy-gage part.

[Claim 2] Said thin-walled part is an ultrasonic transducer according to claim 1 characterized by locating the centrum in the comparatively long direction to said heavy-gage part.

[Claim 3] The thin-walled part of said case object pars basilaris ossis occipitalis is an ultrasonic transducer according to claim 1 or 2 characterized by being thinner than the minimum thickness of the side attachment wall of a case object.

[Claim 4] The external surface of the pars basilaris ossis occipitalis of said case object is an ultrasonic transducer according to claim 1, 2, or 3 characterized by being flat.

[Claim 5] The ultrasonic transducer according to claim 1, 2, 3, or 4 characterized by having an insulating ingredient on said thin-walled part.

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the ultrasonic transducer used for obstruction detection sensors, such as a back sonar of an automobile, and corner sonar, etc.

[0002]

[Description of the Prior Art] An ultrasonic transducer performs sensing using a supersonic wave, transmits an ultrasonic pulse signal intermittently from a piezo-electric oscillating component, and detects a body by receiving the reflected wave from the obstruction which exists on the outskirts with a piezo-electric oscillating component. As an object for mount, the ultrasonic transducer 1 as shown in drawing 1 is known among this kind of supersonic waves. This ultrasonic transducer 1 forms the centrum 3 of the shape of a cylinder to which the cross section made the shape of a perfect circle the case object 2. The pars-basilaris-ossis-occipitalis 2a inside of the case object 2 is made to fix the plate-like piezo-electric oscillating component 4 dedicated in this centrum 3. The signal line 6 of one of the two of the connector cable 5 is connected to the one side electrode of the piezo-electric oscillating component 4, and the another side electrode of the piezo-electric oscillating component 4 is made to flow through the signal line 6 of another side of the connector cable 5 electrically through the metal case object 2. In addition, the signs 7 in drawing are acoustic material,

such as wrap felt, about the piezo-electric oscillating component 4, and 8 is insulating resin which has elasticity, such as silicone rubber and polyurethane rubber, and they have sealed the piezo-electric oscillating component 4 and acoustic material 7.

[0003] By the way, the ultrasonic transducer for mount is attached in the bumper (not shown) of an automobile etc., is used as an obstruction detection sensor like a back sonar or a corner sensor, and at the time of the installation to a bumper, after making almost perpendicular to a road surface the case object pars basilaris ossis occipitalis which the piezo-electric oscillating component fixed and carrying out positioning adjustment towards the direction of acoustic emission, it is arranged. If it is in the ultrasonic transducer used for such an application, if the transmission-and-reception wave range of the supersonic wave in the level installation direction is too narrow, a dead angle will arise in the detection range, and if the transmission-and-reception wave range of the supersonic wave in a perpendicular direction is too wide, the reflected wave from the ground will serve as a noise. Therefore, if it is in the above-mentioned ultrasonic transducer 1, by attaching outside the outside of the case object 2 the ultrasonic horn 9 which carried out the shape of a trumpet, the transmission-and-reception wave range of a supersonic wave is regulated, the transmission-and-reception wave range of the supersonic wave in the level installation direction is wide, and the directional characteristics of an ultrasonic transducer 1 are controlled so that the transmission-and-reception wave range of the supersonic wave in the perpendicular installation direction becomes narrow.

[0004] However, when it was the approach of attaching an ultrasonic horn and controlling the directional characteristics of an ultrasonic transducer, there was a problem which the storm sewage which has splashed from a road by the tire, earth and sand, dust, etc. may be collected and got blocked in an ultrasonic horn, and malfunction of an ultrasonic transducer generates. Moreover, directional characteristics changed with deformation of an ultrasonic horn, and there was a problem to which an ultrasonic transducer benefits an ultrasonic horn large.

[0005] Then, the approach of controlling the directional characteristics of an ultrasonic transducer is proposed, without using an ultrasonic horn. This ultrasonic transducer 11 forms the centrum 13 to which horizontal cross sectional view carried out the shape of the shape of an abbreviation rectangle, and an abbreviation ellipse in the case object 12, and makes the pars basilaris ossis occipitalis 14 of this case object 12 fix the disc-like piezo-electric oscillating component 15, as shown in drawing 2 (only a case object is shown). If the case object 12 of such structure is used, since a supersonic wave will breadth-come to be easy in the direction where the width of face of a centrum 13 is small, while making large the transmission-and-reception wave range of the supersonic wave in the level installation direction, the transmission-and-reception wave range of the supersonic wave in the perpendicular installation direction can be narrowed.

[0006] For example, in the ultrasonic transducer whose outer diameter D is 18mm, to the transmission-and-reception wave range of the level installation direction being 80 degrees, the transmission-and-reception wave range of the perpendicular installation direction is as narrow as 60 degrees, and a remarkable anisotropy is seen.

[0007]

[Problem(s) to be Solved by the Invention] However, in the ultrasonic transducer of the above structures, when the ultrasonic transducer became small, the transmission-and-reception wave range of the perpendicular installation direction became large, the difference of the transmission-and-reception wave range became small in the level installation direction and the perpendicular installation direction, and the anisotropy was seldom seen.

[0008] For example, as shown in drawing 2 , the whole height H dedicates the piezo-electric oscillating component 15 whose diameter d is 7mm to the case [where the outer diameter D which extended the vertical internal surface of a centrum 13 in the perpendicular installation direction is 14mm] object 12 so that 13mm and width of face W may be set to 8mm, and fixes the piezo-electric oscillating component 15 to the inside of a pars basilaris ossis occipitalis 14.

Moreover, the pars basilaris ossis occipitalis 14 of this case object 12 is uniform thickness, that board thickness T is 0.7mm, and the minimum thickness of the side-attachment-wall section of the case object 12 is 0.5mm. The level installation direction and the perpendicular installation direction came to show the directional characteristics of such an ultrasonic transducer of a dimension to drawing 3 , respectively, to the transmission-and-reception wave range of the level installation direction (reduction-by-half full width) being 80 degrees, the transmission-and-reception wave range of the perpendicular installation direction (reduction-by-half full width) was as wide as 70 degrees, and the anisotropy of directional characteristics was seldom seen for the ultrasonic transducer whose outer diameter D is 18mm in the level installation direction and the perpendicular installation direction. In addition, the reduction-by-half full width used for evaluation of the transmission-and-reception wave range is an include angle between the directions which serve as a decrease of 20log(s)0.5dB (about 60dB) from front (0-degree direction) transmission-and-reception sensibility.

[0009] The place which this invention is made in view of the fault of the above-stated conventional example, and is made into the purpose is to offer the ultrasonic transducer which can enlarge the anisotropy of the directional characteristics in the level installation direction and the perpendicular installation direction also in the case of a small ultrasonic transducer.

[0010]

[Description of the Invention] The ultrasonic transducer indicated to claim 1 is comparatively long in an one direction in a cross section parallel to the pars basilaris ossis occipitalis of a case object, it prepares the centrum which became comparatively short in a case object in another direction, prepares a heavy-gage part and a thin-walled part in said pars basilaris ossis occipitalis in the ultrasonic transducer which has arranged the piezo-electric oscillating component dedicated in this centrum to the inside of said case object pars basilaris ossis occipitalis located in a centrum base, and is characterized by to have arranged said piezo-electric oscillating component to a heavy-gage part.

[0011] Without using an ultrasonic horn, since the thin-walled part is prepared in the pars basilaris ossis occipitalis of a case object which prepared the centrum with a comparatively long diameter distance in an one direction, and a comparatively short diameter distance in the other directions according to the ultrasonic transducer indicated to claim 1, a centrum can narrow the directional characteristics of the ultrasonic transducer in a comparatively long direction, and can make high the anisotropy of the directional characteristics in the direction where a centrum is comparatively long, and a comparatively short direction. A high anisotropy can be acquired also when an ultrasonic transducer is miniaturized especially. And since the heavy-gage part instead of a thin-walled part at the base of a case object are made to fix a piezo-electric oscillating component, a piezo-electric oscillating component does not break by the impact from the outside. Therefore, the shock resistance of the ultrasonic transducer equipped with the high directional characteristics of an anisotropy improves, and the utilization is attained. Moreover, since the reinforcement at the base of a case object can be made to hold by the heavy-gage part, thickness of a thin-walled part can be made thinner and the anisotropy of directional characteristics can be made more remarkable.

[0012] As for said thin-walled part, it is desirable to locate the centrum in the comparatively long direction to the heavy-gage part of a case object pars basilaris ossis occipitalis like the embodiment indicated to claim 2. By locating a thin-walled part in the comparatively long direction of a centrum, the transmission-and-reception wave range in the comparatively long direction of a centrum can be narrowed, and it is effective making the anisotropy of the directional characteristics of an ultrasonic transducer high. Moreover, as for the thin-walled part of a case object pars basilaris ossis occipitalis, it is desirable to make it thinner than the minimum thickness of the side attachment wall of a case object like the embodiment indicated to claim 3.

[0013] The embodiment according to claim 4 is characterized by making flat the external surface of the pars basilaris ossis occipitalis of said case object in the

ultrasonic transducer according to claim 1, 2, or 3. Although characterized by the ultrasonic transducer of this invention preparing a heavy-gage part and a thin-walled part in the pars basilaris ossis occipitalis of a case object, since a case object pars basilaris ossis occipitalis serves as an ultrasonic transmission-and-reception wave front, if irregularity is in the external surface of a case object pars basilaris ossis occipitalis, the directional characteristics of an ultrasonic transducer will be confused. In the ultrasonic transducer indicated to claim 4, since the external surface of a case pars basilaris ossis occipitalis used as an ultrasonic transmission-and-reception wave front is made flat, a good ultrasonic transmission-and-reception wave property can be acquired.

[0014] The embodiment according to claim 5 is characterized by having an insulating ingredient on said thin-walled part according to claim 1, 2, 3, or 4. If it is in the ultrasonic transducer by this embodiment, since an unnecessary vibration of a thin-walled part can be attenuated with the insulating ingredient on a thin-walled part, the lower limit of detection distance can be shortened by controlling the reverberation of an ultrasonic transducer.

[0015]

[Embodiment of the Invention] The ultrasonic transducer 30 concerning 1 operation gestalt of this invention is explained with reference to drawing 4 and drawing 5 . The structure of the case object 31 used for the ultrasonic transducer 30 of this operation gestalt is shown in drawing 5 . Drawing 5 (a) is [the sectional view of the perpendicular installation direction and drawing 5 (c) of the plane section Fig. of the case object 31 and drawing 5 (b)] the sectional views of the level installation direction. The case object 31 is equipped with the centrum 33 which the whole is formed with metallic materials, such as aluminum, and carried out opening at the tooth back, in the perpendicular installation direction of an ultrasonic transducer 30, as a centrum 33 deletes the both-sides wall 34, it is extended, and the diameter die length of the perpendicular installation direction is longer than the diameter die length of the level installation direction. The piezo-electric oscillating component 35 is dedicated in this centrum 33, and the piezo-

electric oscillating component 35 has fixed to that pars-basilaris-ossis-occipitalis 32 inside.

[0016] Thin-walled part 32b to which the center section of the perpendicular installation direction made abbreviation falcation the both sides by being set to heavy-gage part 32a is prepared, and the one side electrode surface of the piezo-electric oscillating component 35 has fixed the pars basilaris ossis occipitalis 32 of the case object 31 with electroconductive glue etc. to the inside of heavy-gage part 32a in pars-basilaris-ossis-occipitalis 32 center. Therefore, in the cross section of the perpendicular installation direction, as shown in drawing 5 (b), thin-walled part 32b is located in the both sides of heavy-gage part 32a which had the piezo-electric oscillating component 35 mounted, and in the cross section of the level installation direction passing through the core of the case object 31, as shown in drawing 5 (c), the pars-basilaris-ossis-occipitalis 32 whole has become heavy-gage part 32a. The thickness of this heavy-gage part 32a is thicker than the minimum thickness of the periphery side-attachment-wall section 34 of the case object 31, and the thickness of thin-walled part 32b is thinner than the minimum thickness of the periphery side-attachment-wall section 34 of the case object 31.

[0017] If it is in an ultrasonic transducer 30, as shown in drawing 4 , the interior of the above case objects 31 is filled up with the acoustic material 36, such as felt, and the insulating ingredient 37 which has elasticity, such as silicone rubber and polyurethane rubber, and the interior of the case object 31 is closed. On the other hand, in the insulating ingredient 37, the veneer capacitor 38 for temperature compensations is embedded, the one side external electrode of the veneer capacitor 38 was connected to the electrode surface and the case object 31 which flowed of the piezo-electric oscillating component 35 with lead wire 39, and the another side external electrode of the veneer capacitor 38 is connected to the another side electrode of the piezo-electric oscillating component 35 with lead wire 39. Furthermore, two signal lines 41 for signal I/O which constitute a cable 40 are connected to each external electrode of the veneer capacitor 38.

[0018] This ultrasonic transducer 30 is used for example, for mount, turns the direction where the width of face of a centrum 33 is long in the direction almost perpendicular to a road surface, turns to a horizontal direction almost parallel to a road surface the direction where the width of face of a centrum 33 is short, turns the pars basilaris ossis occipitalis 32 of the case object 31 in the detection direction, and is attached in a car etc.

[0019] According to the ultrasonic transducer 30 of this invention which has the above structures, the transmission-and-reception wave range in the perpendicular installation direction (direction where the width of face of a centrum 33 is long) can be narrowed. Also when an ultrasonic transducer 30 is miniaturized especially, the transmission-and-reception wave range of the perpendicular installation direction cannot become large easily, and the small transmission-and-reception wave range can be maintained in the perpendicular installation direction. Consequently, the difference of the transmission-and-reception wave range of the level installation direction and the transmission-and-reception wave range of the perpendicular installation direction can be enlarged, and also when it is the small ultrasonic transducer 30, the anisotropy of directional characteristics can be enlarged.

[0020] Thickness of the whole case object pars basilaris ossis occipitalis of an ultrasonic transducer may be made thin, without preparing a heavy-gage part, in order to narrow the transmission-and-reception wave range in the perpendicular installation direction and to enlarge the anisotropy of directional characteristics. Drawing 6 and Table 1 show change of the transmission-and-reception wave range (reduction-by-half full width) in the perpendicular installation direction when changing the thickness of a case object pars basilaris ossis occipitalis (pars basilaris ossis occipitalis of thickness with the uniform whole) to 0.7mm - 0.3mm in the ultrasonic transducer whose outer diameter (D) is 18mm.

[0021]

[Table 1]

ケース体底部の厚み（mm）	0.3	0.4	0.5	0.6	0.7
半減全角（°）	30	40	48	54	60

[0022] Moreover, drawing 7 and Table 2 show change of the transmission-and-reception wave range (reduction-by-half full width) in the perpendicular installation direction when changing the thickness of a case object pars basilaris ossis occipitalis (pars basilaris ossis occipitalis of thickness with the uniform whole) to 0.7mm - 0.3mm in the ultrasonic transducer whose outer diameter (D) is 14mm.

[0023]

[Table 2]

ケース体底部の厚み（mm）	0.3	0.4	0.5	0.6	0.7
半減全角（°）	40	50	58	64	70

[0024] According to drawing 6 , drawing 7 , and Table 1 and 2, by making thin thickness of a case object pars basilaris ossis occipitalis also in an ultrasonic transducer with an outer diameter of 14mm also in an ultrasonic transducer with an outer diameter of 18mm shows that the transmission-and-reception wave range can be narrowed. And an ultrasonic transducer becomes small and the one where an outer-diameter dimension is smaller is also known by that the transmission-and-reception wave range spreads. for example, since [whose thickness of a pars basilaris ossis occipitalis is 0.7mm] each **, by the example, although it is the outer diameter of 18mm, and a 14mm thing and transmission-and-reception wave range is 60 degrees and 70 degrees, respectively, if thickness of a pars basilaris ossis occipitalis is set to 0.3mm, the transmission-and-reception wave range will have become narrow to 30 degrees and 40 degrees, respectively.

[0025] Thus, what is necessary is just to make thickness of a case object pars basilaris ossis occipitalis as thin as possible, in order to narrow the transmission-

and-reception wave range of the perpendicular installation direction. However, if the whole pars basilaris ossis occipitalis of a case object is made into a thin-walled part and a piezo-electric oscillating component is fixed to a thin-walled part, a piezo-electric oscillating component will become easy to get an impact from the outside, and a piezo-electric oscillating component will become easy to break by the impact from the outside. For this reason, when the whole pars basilaris ossis occipitalis of a case object is made into a thin-walled part, utilization of the big small ultrasonic transducer of an anisotropy becomes difficult. Or if the shock resistance of an ultrasonic transducer is taken into consideration, there is a limit also in making thin thickness of a case object pars basilaris ossis occipitalis, and sufficient anisotropy cannot be acquired.

[0026] On the other hand, in the ultrasonic transducer 30 of this invention, since heavy-gage part 32a and thin-walled part 32b are prepared in the case object pars basilaris ossis occipitalis 32 and heavy-gage part 32a is made to fix the piezo-electric oscillating component 35, by vibration of the piezo-electric oscillating component 35, it is hard coming to damage the case object pars basilaris ossis occipitalis 32, and thickness of thin-walled part 32b can be made thin. Therefore, the high ultrasonic transducer 30 of the anisotropy in the level installation direction and the perpendicular installation direction is utilizable. For example, as shown in drawing 8 , the outer diameter D of the case object 31 sets [minimum thickness t of 14mm and the periphery side-attachment-wall section 34 / the thickness T2 of 0.5mm and heavy-gage part 32a / the thickness T1 of 0.7mm and thin-walled part 32b] to the ultrasonic transducer 30 which is 0.3mm. Coming to the pars basilaris ossis occipitalis 32 with a radius of R= 6.5mm, supposing the radius of heavy-gage part 32a was mm (R-L), change of the transmission-and-reception wave range of the ultrasonic transducer 30 to ratio L/R of thin-walled part 32b (reduction-by-half full width) was as in drawing 9 and Table 3.

[0027]

[Table 3]

薄肉部の比率（L／R）	0	0.1	0.2	0.3	0.4
半減全角（°）	70	65	60	55	48

[0028] It turns out that the transmission-and-reception wave range of an ultrasonic transducer 30 (reduction-by-half full width) becomes narrow gradually as shown in drawing 9 or Table 3 and ratio L/R of thin-walled part 32b in the case object pars basilaris ossis occipitalis 32 becomes large. Since the diameter of the piezo-electric oscillating component 35 was 0.7mm, when it could make the piezo-electric oscillating component 35 fix on heavy-gage part 32a when the range of L/R was 0-0.4, especially the ratio of a thin-walled part was L/R=0.4 and the pars-basilaris-ossis-occipitalis 32 whole was set to thin-walled part 32b, it was able to attain the near transmission-and-reception wave range.

[0029] The transmission-and-reception wave range [in / drawing 10 is drawing showing the comparison with the conventional ultrasonic transducer, and / in a diameter / the perpendicular installation direction of the 18mm (phi 18) conventional ultrasonic transducer (the thickness of a pars basilaris ossis occipitalis is 0.7mm)], The transmission-and-reception wave range [in / in a diameter / the perpendicular installation direction of the 14mm (phi 14) conventional ultrasonic transducer (the thickness of a pars basilaris ossis occipitalis is 0.7mm)] and the transmission-and-reception wave range in the perpendicular installation direction of the ultrasonic transducer 30 by this invention in case ratio L/R of a thin-walled part is about 0.4 are shown. According to this invention, this drawing shows that the transmission-and-reception wave range smaller than an ultrasonic transducer with a diameter [of the conventional example] of 18mm is realizable with the ultrasonic transducer 30 with a diameter of 14mm.

[0030] Moreover, drawing 11 is the ultrasonic transducer 30 using the case object 31 of structure like drawing 5 , and a diameter is 14mm and it turns out that the thickness of 0.75mm and thin-walled part 32b is 0.3mm, and the thickness of heavy-gage part 32a shows the directional characteristics in the

level installation direction in L/R=2.5mm/6.5mm=0.38, and the directional characteristics in the perpendicular installation direction, and can realize a quite strong anisotropy.

[0031] The top view and drawing 12 (b) which show the structure of the case object 31 where drawing 12 (a) is used for the ultrasonic transducer by another operation gestalt of this invention are the E-E line sectional view of this drawing (a). The case object 31 of this ultrasonic transducer has the long centrum 33 in the perpendicular installation direction, and long heavy-gage part 32a is prepared in the center section of the pars basilaris ossis occipitalis 32 of the case object 31 in the level installation direction. In the center section of heavy-gage part 32a, the piezo-electric oscillating component 35 has fixed with electroconductive glue, and thin-walled part 32b which carried out falcation is prepared in the both sides located in the perpendicular installation direction of heavy-gage part 32a. The tabular insulating ingredient 42 which consists of resin ingredients, such as silicon resin, urethane resin, and synthetic rubber, is formed in the top face of thin-walled part 32b.

[0032] If an unnecessary vibration arises in thin-walled part 32b of the case object 31, since it will interfere with the supersonic wave reflected from the body with which the reverberation of an ultrasonic transducer increased and such reverberation approached the ultrasonic transducer, it becomes impossible to detect existence of the body which approached when unnecessary vibration of thin-walled part 32b became large, and it becomes impossible to measure the distance to the body which approached.

[0033] With the operation gestalt shown in drawing 12 , an unnecessary vibration of thin-walled part 32b is attenuated by forming the insulating ingredient 42 on thin-walled part 32b. Since unnecessary vibration can be attenuated with the insulating ingredient 42 prepared on thin-walled part 32b according to the ultrasonic transducer using such a case object 31, the reverberation time can be shortened. Therefore, interference with the supersonic wave reflected from the body close to an ultrasonic transducer and the reverberation generated with the

ultrasonic transducer can be prevented, and existence of the body which approached can be detected, and the lower limit of detection distance can be shortened.

[0034] Drawing 13 is drawing showing the reverberation property of an ultrasonic transducer of having used the case object of drawing 12 , an axis of abscissa shows the thickness of the insulating ingredient 42, and the axis of ordinate expresses reverberation time. Reverberation time becomes short as shown in this reverberation property Fig. and the thickness of the insulating ingredient 42 becomes large. Therefore, what is necessary is just to set up the thickness of the insulating ingredient 42 so that it may become the reverberation time with which the property is filled if the property required of an ultrasonic transducer is decided.

[0035] Although the reverberation time of an ultrasonic transducer has that one or less ms is desirable, what is necessary will be just to set up the thickness of the insulating ingredient 42 more than about 0.9mm or it in this case practically. On the other hand, if the thickness of the insulating ingredient 42 becomes not much large too much, even the supersonic wave for detection or measurement declines, and it is not desirable. Therefore, as for the thickness of the insulating ingredient 42, it is desirable that it is about 2.1mm or less.

[0036] In addition, in the above-mentioned operation gestalt, although the boundary of a heavy-gage part and a thin-walled part is formed stair-like, this boundary may serve as a smooth inclination. However, as for the external surface of a case object, it is desirable to make it a flat surface so that the transmission-and-reception property of an ultrasonic transducer may not be spoiled.

[Translation done.]

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the sectional view showing the structure of the conventional ultrasonic transducer.

[Drawing 2] The plane section Fig. in which (a) shows the important section structure of the conventional ultrasonic transducer, and (b) are the A-A line sectional views of (a).

[Drawing 3] It is drawing showing the directional characteristics of the conventional ultrasonic transducer shown in drawing 2 .

[Drawing 4] It is the sectional view showing the structure of the ultrasonic transducer concerning 1 operation gestalt of this invention.

[Drawing 5] The B-B line sectional view (cross section of the perpendicular installation direction) of (a) and (c of the plane section Fig. in which (a) shows the case object of an ultrasonic transducer same as the above, and (b)) are the C-C line sectional views (cross section of the level installation direction) of (a).

[Drawing 6] It is drawing showing change of the reduction-by-half full width of the perpendicular installation direction over the thickness of a case object pars basilaris ossis occipitalis with the conventional ultrasonic transducer.

[Drawing 7] It is drawing showing change of the reduction-by-half full width of the perpendicular installation direction over the thickness of a case object pars basilaris ossis occipitalis with another conventional ultrasonic transducer.

[Drawing 8] It is the sectional view showing the case object of the ultrasonic transducer of this invention used for measurement of directional characteristics.

[Drawing 9] It is drawing showing change of the reduction-by-half full width when

changing the ratio of a thin-walled part in an ultrasonic transducer same as the above.

[Drawing 10] It is drawing which compares the directional characteristics of the conventional ultrasonic transducer and the ultrasonic transducer of this invention.

[Drawing 11] It is drawing which compares the directional characteristics in the level installation direction and the perpendicular installation direction of an ultrasonic transducer of this invention.

[Drawing 12] The top view showing the structure of the case object of the ultrasonic transducer according [(a)] to another operation gestalt of this invention and (b) are the E-E line sectional views of (a).

[Drawing 13] It is drawing showing the reverberation property of the ultrasonic transducer using a case object same as the above.

[Description of Notations]

1 Case Object Pars Basilaris Ossis Occipitalis

32a Heavy-gage part

32b Thin-walled part

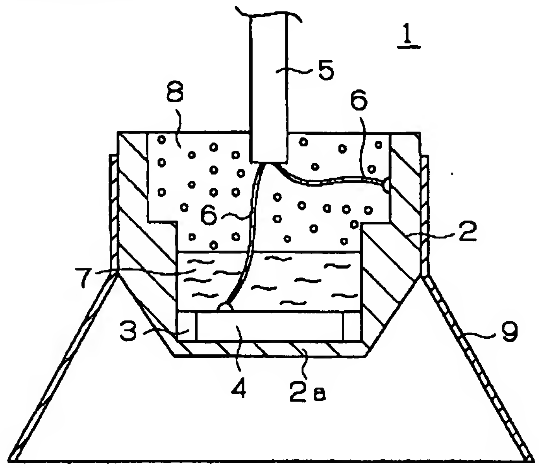
2 Centrum

35 Piezo-electric Oscillating Component

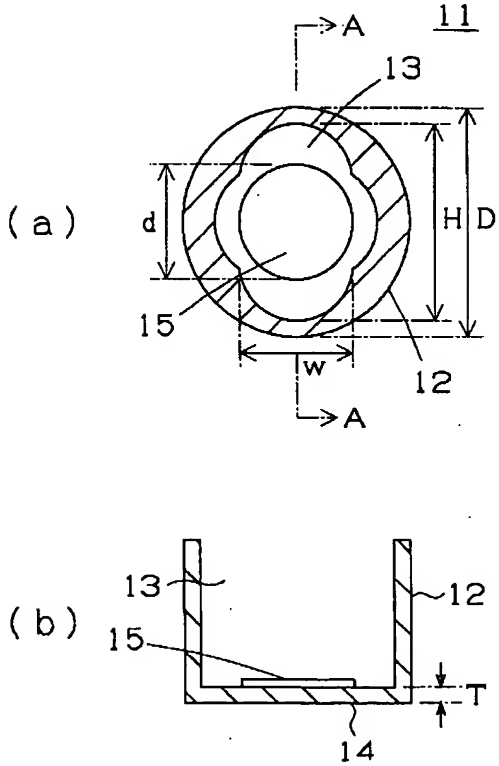
[Translation done.]

DRAWINGS

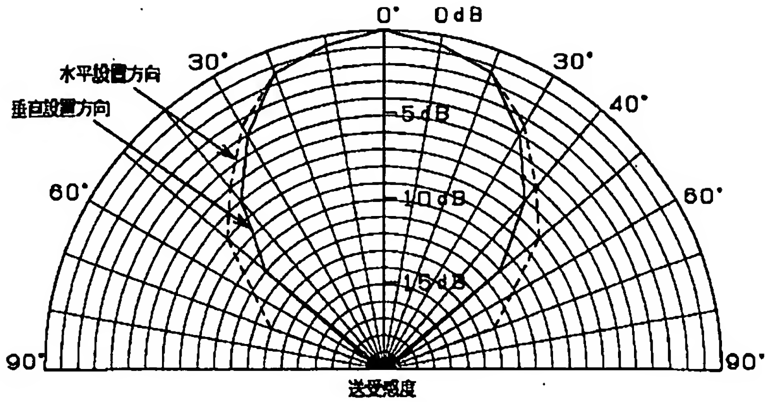
[Drawing 1]



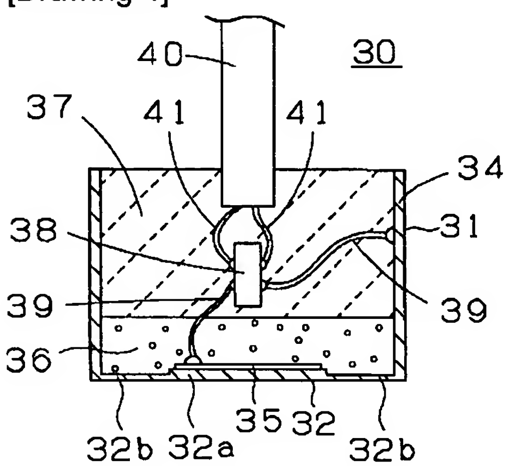
[Drawing 2]



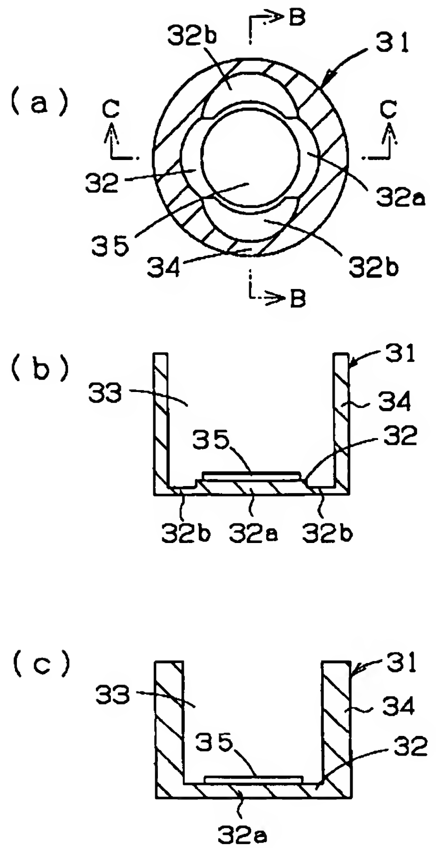
[Drawing 3]



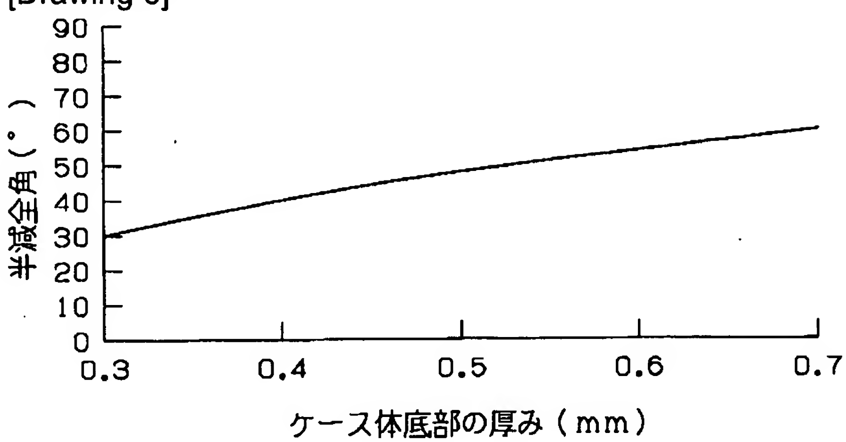
[Drawing 4]



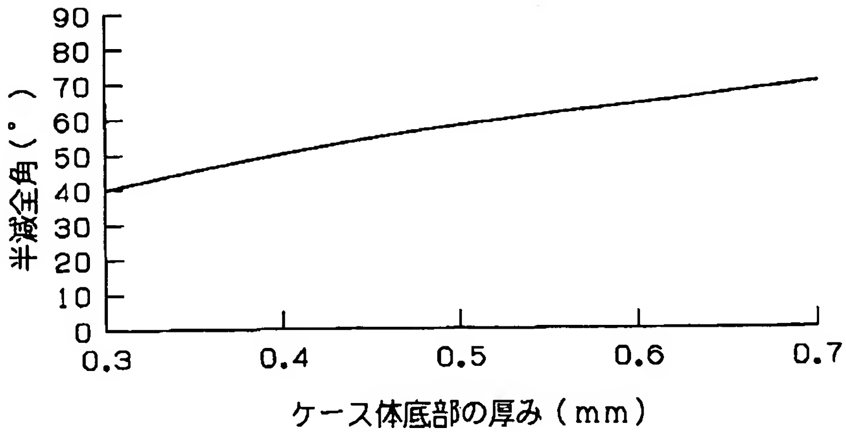
[Drawing 5]



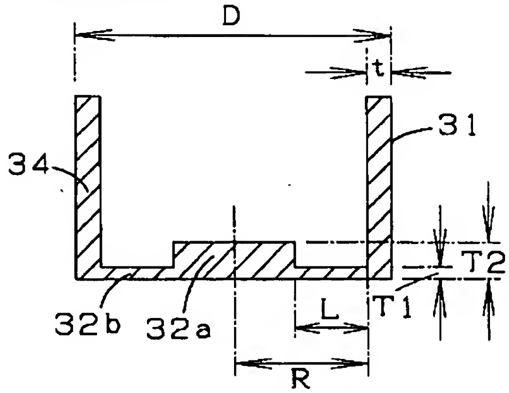
[Drawing 6]



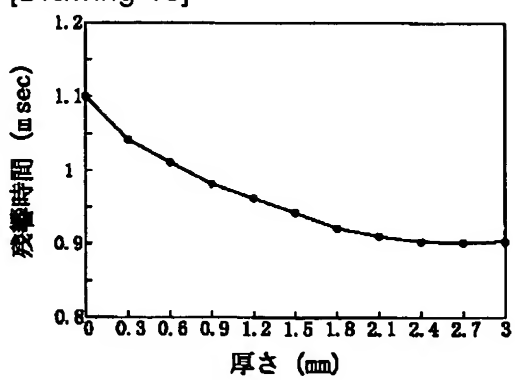
[Drawing 7]



[Drawing 8]



[Drawing 13]



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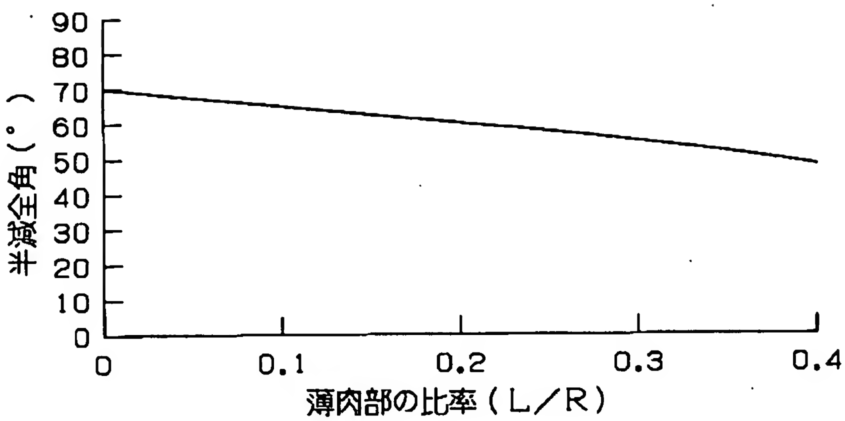

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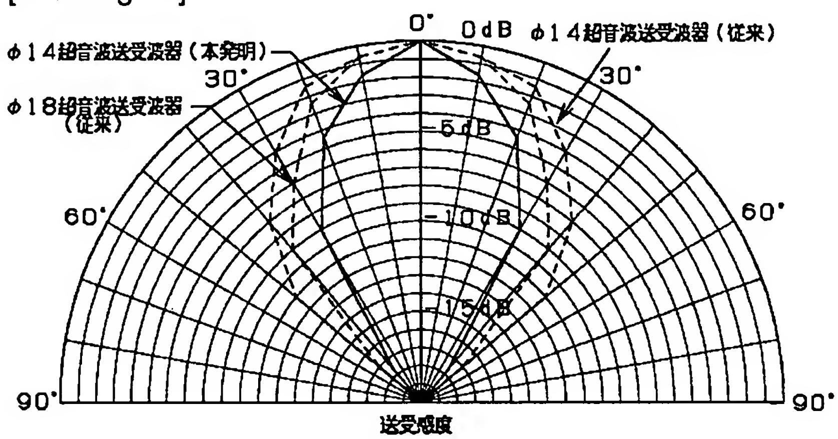

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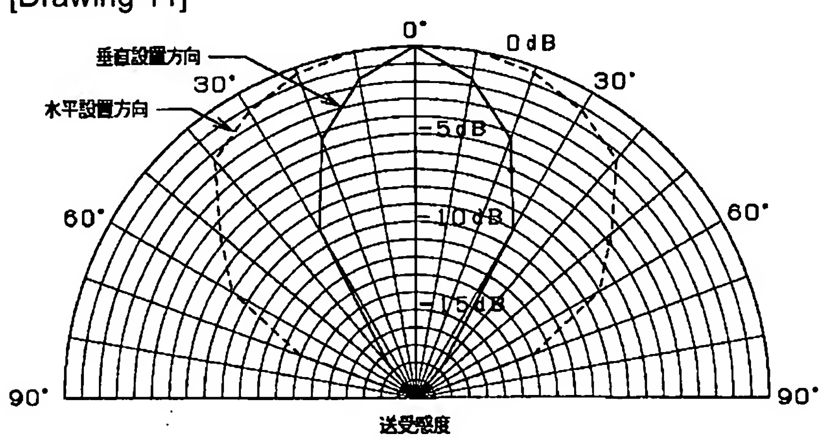

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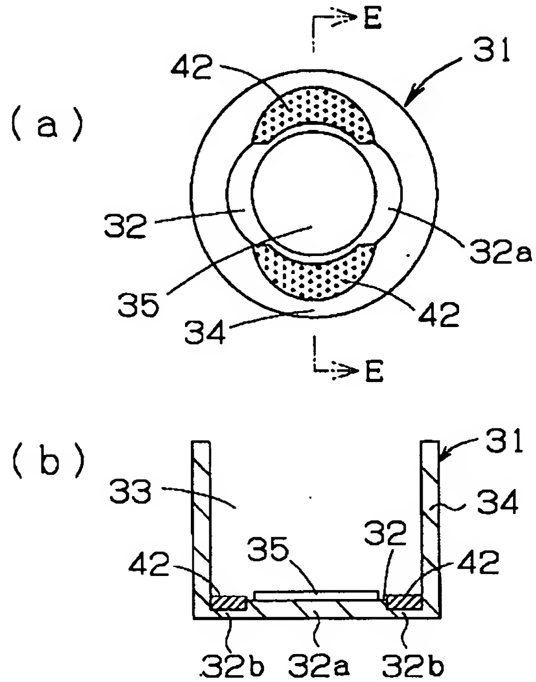

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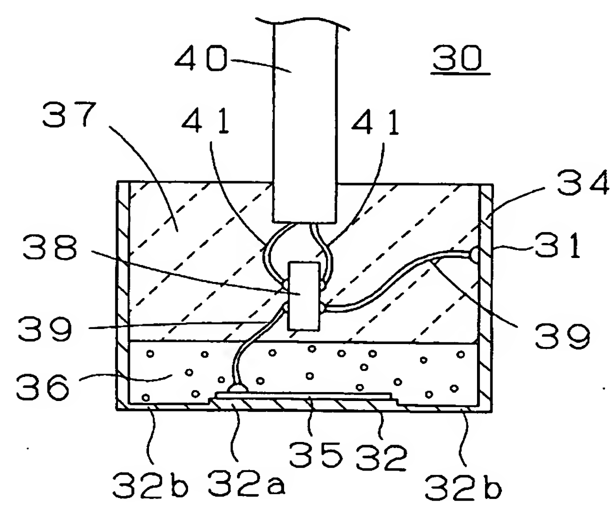
(54)【発明の名称】　超音波送受波器

(57)【要約】

【課題】　小型の超音波送受波器において、垂直設置方向の送受波範囲（半減全角）を狭くし、水平設置方向と垂直設置方向における指向特性の異方性を顕著にする。

【解決手段】　ケース体３１の中空部３３は、水平設置方向に短く、垂直設置方向に長くなるように開口する。ケース体底部（中空部３３の底面）３２の中央部には、厚肉部３２ａを設け、その水平設置方向の両側に薄肉部３２ｂを設けている。圧電振動素子３５は、厚肉部３２ａに固着している。



【特許請求の範囲】

【請求項１】　ケース体の底部と平行な断面において、一方向で比較的長く、別な方向で比較的短くなった中空部をケース体に設け、この中空部内に納めた圧電振動素子を中空部底面に位置する前記ケース体底部の内面に配置した超音波送受波器において、
前記底部に厚肉部と薄肉部とを設け、前記圧電振動素子を厚肉部に配置したことを特徴とする超音波送受波器。

【請求項２】　前記薄肉部は、前記厚肉部に対して、中空部が比較的長い方向に位置していることを特徴とする、請求項１に記載の超音波送受波器。

【請求項３】　前記ケース体底部の薄肉部は、ケース体の側壁の最小厚みよりも薄いことを特徴とする、請求項１又は２に記載の超音波送受波器。

【請求項４】　前記ケース体の底部の外面は、平坦となっていることを特徴とする、請求項１，２又は３に記載の超音波送受波器。

【請求項５】　前記薄肉部上に絶縁性材料を有することを特徴とする、請求項１，２，３又は４に記載の超音波送受波器。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、自動車のバックソナーやコーナーソナー等の障害物検知センサなどに用いられる超音波送受波器に関する。

【０００２】

【従来の技術】超音波送受波器は、超音波を利用してセンシングを行うものであり、圧電振動素子から超音波パルス信号を間欠的に送信し、周辺に存在する障害物からの反射波を圧電振動素子で受信することにより物体を検知するものである。この種の超音波のうち車載用としては、図１に示すような超音波送受波器１が知られている。この超音波送受波器１は、ケース体２に横断面が真円状をした円柱状の中空部３を設け、この中空部３内に納めた平板状の圧電振動素子４をケース体２の底部２ａ内面に固着させ、コネクタケーブル５の片方の信号線６を圧電振動素子４の一方電極に接続し、コネクタケーブル５の他方の信号線６を金属製のケース体２を介して圧電振動素子４の他方電極に電気的に導通させたものである。なお、図中の符号７は、圧電振動素子４を覆うフェルトなどのような吸音材であり、８はシリコンゴムやウレタンゴムなどのような弾性を有する絶縁性樹脂で、圧電振動素子４及び吸音材７を密封している。

【０００３】ところで、車載用の超音波送受波器は、自動車のバンパー（図示せず）などに取り付けられ、バックソナーやコーナセンサのような障害物検知センサとして使用されるものであり、バンパーへの取り付け時には、圧電振動素子の固着されたケース体底部を路面とほぼ垂直とし、超音波放射方向に向けて位置決め調整したうえで配置される。このような用途に用いられる超音波送受波器にあっては、水平設置方向における超音波の送受波範囲が狭すぎると検知範囲に死角が生じ、また、垂直方向における超音波の送受波範囲が広すぎると地面からの反射波がノイズとなる。そのため、上記超音波送受波器１にあっては、ケース体２の外側にラッパ状をした超音波ホーン９を外嵌することによって超音波の送受波範囲を規制し、水平設置方向における超音波の送受波範囲が広く、かつ、垂直設置方向における超音波の送受波範囲が狭くなるように超音波送受波器１の指向特性を制御している。

【０００４】しかしながら、超音波ホーンを取り付けて超音波送受波器の指向特性を制御する方法であると、タイヤにより道路から跳ね上げられた雨水や土砂、塵埃などが超音波ホーン内に溜まって詰まることがあり、超音波送受波器の誤動作が発生する問題があった。また、超音波ホーンの変形によって指向特性が変化したり、超音波ホーンのために超音波送受波器が大きくなってしまう問題があった。

【０００５】そこで、超音波ホーンを用いることなく超音波送受波器の指向特性を制御する方法が提案されている。この超音波送受波器１１は、図２（ケース体のみを示す）に示すように、横断面視が略長方形状もしくは略長円状をした中空部１３をケース体１２に設け、このケース体１２の底部１４に円板状の圧電振動素子１５を固着させたものである。このような構造のケース体１２を用いれば、中空部１３の幅の小さな方向には超音波が広がり易くなるので、水平設置方向における超音波の送受波範囲を広くすると共に垂直設置方向における超音波の送受波範囲を狭くすることができる。

【０００６】例えば、外径Ｄが１８ｍｍの超音波送受波器では、水平設置方向の送受波範囲が８０°であるのに対して垂直設置方向の送受波範囲は６０°と狭く、かなりの異方性が見られる。

【０００７】

【発明が解決しようとする課題】しかしながら、上記のような構造の超音波送受波器では、超音波送受波器が小型になると、垂直設置方向の送受波範囲が広くなり、水平設置方向と垂直設置方向とで送受波範囲の差が小さくなり、あまり異方性が見られなかった。

【０００８】例えば、図２に示すように、全体の高さＨが１３ｍｍ、幅Ｗが８ｍｍとなるように中空部１３の上下内壁面を垂直設置方向に拡張した外径Ｄが１４ｍｍのケース体１２に直径ｄが７ｍｍの圧電振動素子１５を納め、底部１４の内面に圧電振動素子１５を固着したものである。また、このケース体１２の底部１４は均一な厚みで、その板厚Ｔは０．７ｍｍとなっており、ケース体１２の側壁部の最小厚みは０．５ｍｍである。このような寸法の超音波送受波器の指向特性は、水平設置方向と垂直設置方向とでそれぞれ図３に示すようになり、水平設置方向の送受波範囲（半減全角）が８０°であるのに

対して垂直設置方向の送受波範囲（半減全角）は７０°と広く、外径Ｄが１８ｍｍの超音波送受波器ほど水平設置方向と垂直設置方向で指向特性の異方性があまり見られなかった。なお、送受波範囲の評価に用いた半減全角とは、正面（０°の方向）の送受感度よりも２０log０．５ｄＢ（約６０ｄＢ）減となる方向間の角度である。

【０００９】本発明は叙上の従来例の欠点に鑑みてなされたものであり、その目的とするところは、小型の超音波送受波器の場合にも、水平設置方向と垂直設置方向における指向特性の異方性を大きくすることができる超音波送受波器を提供することにある。

【００１０】

【発明の開示】請求項１に記載した超音波送受波器は、ケース体の底部と平行な断面において、一方向で比較的長く、別な方向で比較的短くなった中空部をケース体に設け、この中空部内に納めた圧電振動素子を中空部底面に位置する前記ケース体底部の内面に配置した超音波送受波器において、前記底部に厚肉部と薄肉部とを設け、前記圧電振動素子を厚肉部に配置したことを特徴としている。

【００１１】請求項１に記載した超音波送受波器によれば、一方向における差渡し距離が比較的長く、他方向における差渡し距離が比較的短い中空部を設けたケース体の底部に薄肉部を設けているので、超音波ホーンを用いることなく、中空部が比較的長い方向における超音波送受波器の指向特性を狭くすることができ、中空部が比較的長い方向と比較的短い方向とでの指向特性の異方性を高くすることができる。特に、超音波送受波器を小型化した場合にも高い異方性を得ることができる。しかも、圧電振動素子は、ケース体底面の薄肉部でなく厚肉部に固着させているので、外部からの衝撃によって圧電振動素子が割れることがない。よって、異方性の高い指向特性を備えた超音波送受波器の耐衝撃性が向上し、その実用化が可能になる。また、厚肉部によってケース体底面の強度を保持させることができるので、薄肉部の厚みをより薄くすることができ、指向特性の異方性をより顕著にすることができる。

【００１２】前記薄肉部は、請求項２に記載した実施態様のように、ケース体底部の厚肉部に対して、中空部が比較的長い方向に位置していることが望ましい。薄肉部を中空部の比較的長い方向に位置させることにより、中空部の比較的長い方向における送受波範囲を狭くすることができ、超音波送受波器の指向特性の異方性を高くするのにより効果がある。また、ケース体底部の薄肉部は、請求項３に記載した実施態様のように、ケース体の側壁の最小厚みよりも薄くすることが望ましい。

【００１３】請求項４に記載の実施態様は、請求項１，２又は３に記載の超音波送受波器において、前記ケース体の底部の外面を平坦にしたことを特徴としている。本発明の超音波送受波器はケース体の底部に厚肉部と薄肉部を設けたことを特徴としているが、ケース体底部は超音波送受波面となるものであるから、ケース体底部の外面に凹凸があると、超音波送受波器の指向特性が乱れる。請求項４に記載した超音波送受波器では、超音波送受波面となるケース底部の外面を平坦にしているので、良好な超音波送受波特性を得ることができる。

【００１４】請求項５に記載の実施態様は、請求項１，２，３又は４に記載の前記薄肉部上に絶縁性材料を有することを特徴としている。この実施態様による超音波送受波器にあっては、薄肉部上の絶縁性材料により薄肉部の不要な振動を減衰させることができるから、超音波送受波器の残響を抑制することにより、検出距離の下限値を短くすることができる。

【００１５】

【発明の実施の形態】本発明の一実施形態に係る超音波送受波器３０を図４及び図５を参照して説明する。本実施形態の超音波送受波器３０に用いられているケース体３１の構造を図５に示す。図５（ａ）はケース体３１の平断面図、図５（ｂ）は垂直設置方向の断面図、図５（ｃ）は水平設置方向の断面図である。ケース体３１は全体がアルミニウム等の金属材料で形成されていて背面で開口した中空部３３を備えており、中空部３３は超音波送受波器３０の垂直設置方向において両側壁部３４を削るようにして拡張されており、垂直設置方向の差渡し長さが水平設置方向の差渡し長さよりも長くなっている。この中空部３３内には圧電振動素子３５が納められており、その底部３２内面に圧電振動素子３５が固着されている。

【００１６】ケース体３１の底部３２は、垂直設置方向の中央部が厚肉部３２ａとなり、その両側に略三日月状をした薄肉部３２ｂが設けられており、底部３２中央において厚肉部３２ａの内面には、導電性接着剤等によって圧電振動素子３５の一方電極面が固着されている。従って、垂直設置方向の断面においては、図５（ｂ）に示すように圧電振動素子３５を実装された厚肉部３２ａの両側に薄肉部３２ｂが位置しており、ケース体３１の中心を通る水平設置方向の断面においては、図５（ｃ）に示すように、底部３２全体が厚肉部３２ａとなっている。この厚肉部３２ａの厚みは、ケース体３１の外周側壁部３４の最小厚みよりも厚くなっており、薄肉部３２ｂの厚みは、ケース体３１の外周側壁部３４の最小厚みよりも薄くなっている。

【００１７】超音波送受波器３０にあっては、図４に示すように、上記のようなケース体３１の内部にフェルト等の吸音材３６と、シリコンゴムやウレタンゴム等の弾性を有する絶縁性材料３７とを充填し、ケース体３１の内部を封止している。絶縁性材料３７内には、温度補償用の単板コンデンサ３８が埋め込まれており、単板コンデンサ３８の一方外部電極をリード線３９によって圧電振動素子３５の一方電極面と導通したケース体３１に接

続し、単板コンデンサ３８の他方外部電極をリード線３９によって圧電振動素子３５の他方電極に接続している。さらに、ケーブル４０を構成する信号入出力用の２本の信号線４１は、単板コンデンサ３８の各外部電極に接続している。

【００１８】この超音波送受波器３０は、例えば車載用に用いられるものであって、中空部３３の幅の長い方向を路面とほぼ垂直な方向に向け、中空部３３の幅の短い方向を路面とほぼ平行な水平方向に向け、ケース体３１の底部３２を検知方向に向けて車両等に取り付けられる。

【００１９】上記のような構造を有する本発明の超音波送受波器３０によれば、垂直設置方向（中空部３３の幅の長い方向）における送受波範囲を狭くすることができる。特に、超音波送受波器３０を小型化した場合にも、垂直設置方向の送受波範囲が広くなりにくく、垂直設置方向で小さな送受波範囲を維持することができる。この結果、水平設置方向の送受波範囲と垂直設置方向の送受波範囲との差を大きくすることができ、小型の超音波送受波器３０の場合にも指向特性の異方性を大きくすることができる。

【００２０】垂直設置方向における送受波範囲を狭くし、指向特性の異方性を大きくするためには、厚肉部を設けることなく、超音波送受波器のケース体底部全体の厚みを薄くしてもよい。図６及び表１は、外径（Ｄ）が１８mmの超音波送受波器において、ケース体底部（全体が均一な厚みの底部）の厚みを０．７mm～０．３mmまで変化させた時の垂直設置方向における送受波範囲（半減全角）の変化を示している。

【００２１】

【表１】

ケース体底部の厚み（mm）	0.3	0.4	0.5	0.6	0.7
半減全角（°）	30	40	48	54	60

【００２２】また、図７及び表２は、外径（Ｄ）が１４mmの超音波送受波器において、ケース体底部（全体が均一な厚みの底部）の厚みを０．７mm～０．３mmまで変化させた時の垂直設置方向における送受波範囲（半減全角）の変化を示している。

【００２３】

【表２】

ケース体底部の厚み（mm）	0.3	0.4	0.5	0.6	0.7
半減全角（°）	40	50	58	64	70

【００２４】図６、図７、表１及び表２によれば、外径１８mmの超音波送受波器においても外径１４mmの超音波送受波器においても、ケース体底部の厚みを薄くすることによって送受波範囲を狭くすることができるのが分かる。しかも、超音波送受波器が小型になって外径寸法が小さいほうが送受波範囲が広がることも分かる。例えば、底部の厚みが０．７mmの各従来例では、外径１８mmと１４mmのもので、それぞれ送受波範囲は６０°、７０°であるが、底部の厚みを０．３mmにすれば、送受波範囲はそれぞれ３０°、４０°まで狭くなる。

【００２５】このように垂直設置方向の送受波範囲を狭くするためには、ケース体底部の厚みをできるだけ薄くすればよい。しかし、ケース体の底部全体を薄肉部とし、薄肉部に圧電振動素子を固着すると、圧電振動素子が外部からの衝撃を受け易くなり、外部からの衝撃によって圧電振動素子が割れ易くなる。このため、ケース体の底部全体を薄肉部とした場合には、異方性の大きな小型超音波送受波器の実用化が困難になる。あるいは、超音波送受波器の耐衝撃性を考慮すれば、ケース体底部の厚みを薄くするにも限度があり、充分な異方性を得ることができない。

【００２６】これに対し、本発明の超音波送受波器３０では、ケース体底部３２に厚肉部３２ａと薄肉部３２ｂを設け、厚肉部３２ａに圧電振動素子３５を固着させているので、圧電振動素子３５の振動によってケース体底部３２が破損しにくくなり、薄肉部３２ｂの厚みを薄くすることができる。よって、水平設置方向と垂直設置方向とでの異方性の高い超音波送受波器３０を実用化することができる。例えば、図８に示すように、ケース体３１の外径Ｄが１４mm、外周側壁部３４の最小厚みｔが０．５mm、厚肉部３２ａの厚みＴ２が０．７mm、薄肉部３２ｂの厚みＴ１が０．３mmの超音波送受波器３０において、半径Ｒ＝６．５mmの底部３２に対して厚肉部３２ａの半径が（Ｒ－Ｌ）mmであるとするとき、薄肉部３２ｂの比率Ｌ／Ｒに対する超音波送受波器３０の送受波範囲（半減全角）の変化は、図９及び表３のとおりであった。

【００２７】

【表３】

薄肉部の比率（L／R）	0	0.1	0.2	0.3	0.4
半減全角（゜）	70	65	60	55	48

【００２８】図９又は表３から分かるように、ケース体底部３２における薄肉部３２ｂの比率Ｌ／Ｒが大きくなるにつれて、超音波送受器３０の送受波範囲（半減全角）は次第に狭くなることが分かる。圧電振動素子３５の直径は０．７ｍｍであるから、Ｌ／Ｒが０～０．４の範囲であれば圧電振動素子３５を厚肉部３２ａの上に固着させることができ、特に薄肉部の比率がＬ／Ｒ＝０．４の場合には、底部３２全体を薄肉部３２ｂにした場合に近い送受波範囲を達成することができた。

【００２９】図１０は、従来の超音波送受波器との比較を示す図であって、直径が１８ｍｍ（φ１８）の従来の超音波送受波器（底部の厚みが０．７ｍｍ）の垂直設置方向における送受波範囲と、直径が１４ｍｍ（φ１４）の従来の超音波送受波器（底部の厚みが０．７ｍｍ）の垂直設置方向における送受波範囲と、薄肉部の比率Ｌ／Ｒが約０．４の場合の本発明による超音波送受波器３０の垂直設置方向における送受波範囲を示している。この図からは、本発明によれば、直径１４ｍｍの超音波送受波器３０でも、従来例の直径１８ｍｍの超音波送受波器よりも小さな送受波範囲を実現できることが分かる。

【００３０】また、図１１は、図５のような構造のケース体３１を用いた超音波送受波器３０で、直径が１４ｍｍで、厚肉部３２ａの厚みが０．７５ｍｍ、薄肉部３２ｂの厚みが０．３ｍｍで、Ｌ／Ｒ＝２．５ｍｍ／６．５ｍｍ＝０．３８の場合における、水平設置方向における指向特性と垂直設置方向における指向特性とを示しており、かなり強い異方性を実現できることが分かる。

【００３１】図１２（ａ）は本発明の別な実施形態による超音波送受波器に用いられるケース体３１の構造を示す平面図、図１２（ｂ）は同図（ａ）のＥ－Ｅ線断面図である。この超音波送受波器のケース体３１は垂直設置方向に長い中空部３３を有しており、ケース体３１の底部３２の中央部には、水平設置方向に長い厚肉部３２ａが設けられている。厚肉部３２ａの中央部には圧電振動素子３５が導電性接着剤により固着されており、厚肉部３２ａの垂直設置方向に位置する両側には三日月状をした薄肉部３２ｂが設けられている。薄肉部３２ｂの上面には、シリコン樹脂やウレタン樹脂、合成ゴム等の樹脂材料からなる板状の絶縁性材料４２が設けられている。

【００３２】ケース体３１の薄肉部３２ｂに不要な振動が生じると、超音波送受波器の残響が増大し、そのような残響が超音波送受波器に近接した物体から反射された超音波と干渉するので、薄肉部３２ｂの不要振動が大きくなると近接した物体の存在を検知できなくなったり、近接した物体までの距離を測定できなくなったりする。

【００３３】図１２に示した実施形態では、薄肉部３２ｂの上に絶縁性材料４２を設けることにより薄肉部３２ｂの不要な振動を減衰させている。このようなケース体３１を用いた超音波送受波器によれば、薄肉部３２ｂ上に設けられた絶縁性材料４２により不要振動を減衰させることができるので、その残響時間を短くすることができる。そのため、超音波送受波器に近接した物体から反射された超音波と超音波送受波器で発生した残響との干渉を防ぐことができ、近接した物体の存在を検知でき、また検出距離の下限値を短くすることができる。

【００３４】図１３は、図１２のケース体を用いた超音波送受波器の残響特性を示す図であって、横軸は絶縁性材料４２の厚みを示し、縦軸は残響時間を表わしている。この残響特性図から分かるように、絶縁性材料４２の厚みが大きくなるにつれて残響時間は短くなる。したがって、超音波送受波器に要求される特性が決まれば、その特性を満たすような残響時間となるように絶縁性材料４２の厚みを設定すればよい。

【００３５】実用上、超音波送受波器の残響時間は１ミリ秒以下が好ましいことがあるが、この場合には絶縁性材料４２の厚みを約０．９ｍｍかそれ以上に設定すればよいことになる。一方、絶縁性材料４２の厚みがあまり大きくなりすぎると、検知または計測用の超音波までが減衰してしまい、好ましくない。したがって、絶縁性材料４２の厚みは約２．１ｍｍ以下であることが望ましい。

【００３６】なお、上記実施形態においては、厚肉部と薄肉部の境界は階段状に形成されているが、この境界は滑らかな傾斜となっていてもよい。ただし、超音波送受波器の送受特性を損ねないよう、ケース体の外面は平面にするのが好ましい。

【図面の簡単な説明】

【図１】従来の超音波送受波器の構造を示す断面図である。

【図２】（ａ）は従来の超音波送受波器の要部構造を示す平断面図、（ｂ）は（ａ）のＡ－Ａ線断面図である。

【図３】図２に示す従来の超音波送受波器の指向特性を示す図である。

【図４】本発明の一実施形態に係る超音波送受波器の構造を示す断面図である。

【図５】（ａ）は同上の超音波送受波器のケース体を示す平断面図、（ｂ）は（ａ）のＢ－Ｂ線断面図（垂直設置方向の断面）、（ｃ）は（ａ）のＣ－Ｃ線断面図（水平設置方向の断面）である。

【図６】従来の超音波送受波器によりケース体底部の厚

みに対する垂直設置方向の半減全角の変化を示す図である。

【図７】従来の別な超音波送受波器によりケース体底部の厚みに対する垂直設置方向の半減全角の変化を示す図である。

【図８】指向特性の測定に用いた本発明の超音波送受波器のケース体を示す断面図である。

【図９】同上の超音波送受波器において薄肉部の比率を変化させたときの半減全角の変化を示す図である。

【図１０】従来の超音波送受波器と本発明の超音波送受波器との指向特性を比較する図である。

【図１１】本発明の超音波送受波器の、水平設置方向と垂直設置方向における指向特性を比較する図である。

【図１２】（ａ）は本発明の別な実施形態による超音波送受波器のケース体の構造を示す平面図、（ｂ）は（ａ）のＥ－Ｅ線断面図である。

【図１３】同上のケース体を用いた超音波送受波器の残響特性を示す図である。

【符号の説明】

１　ケース体底部

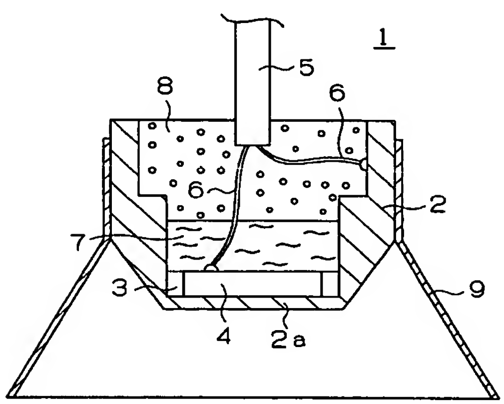
３２ａ　厚肉部

３２ｂ　薄肉部

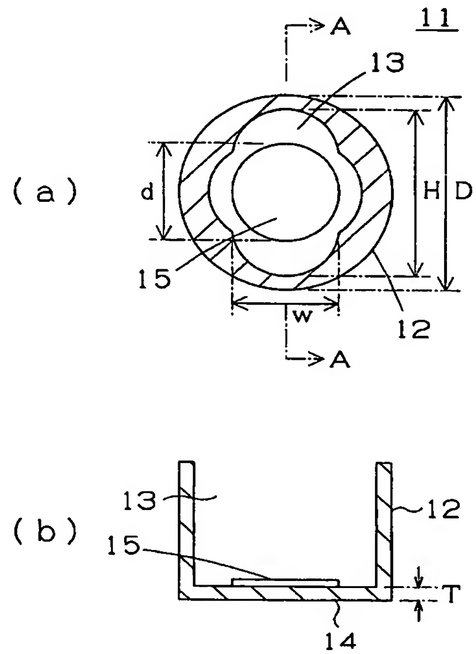
２　中空部

３５　圧電振動素子

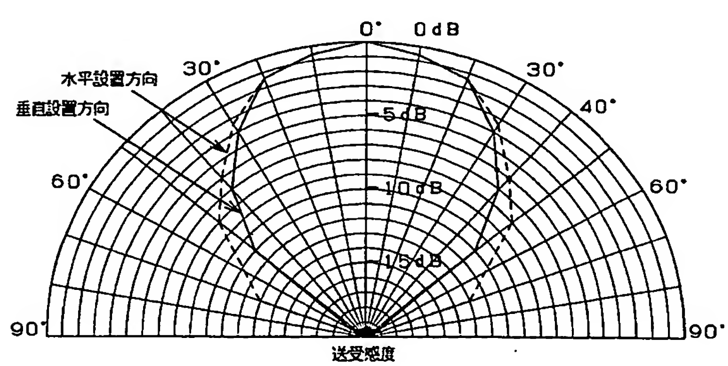
【図１】



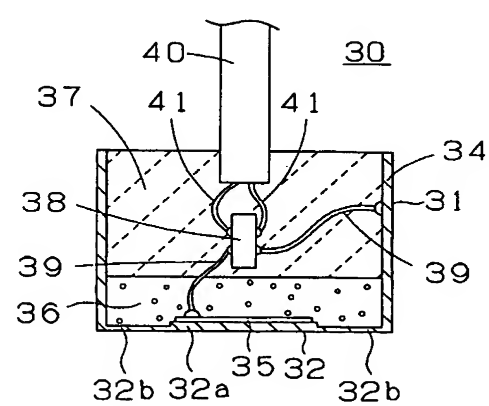
【図２】



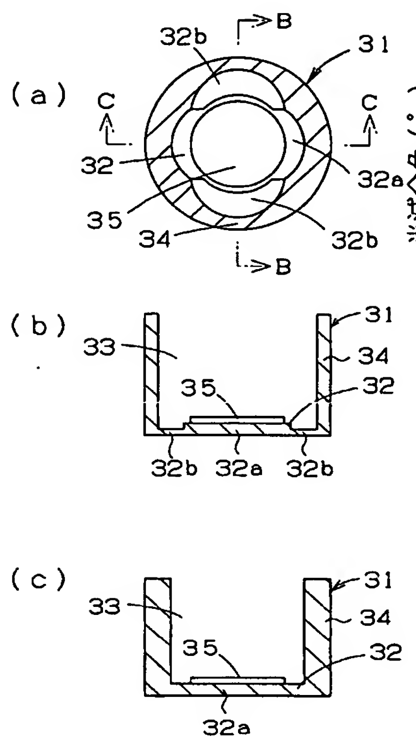
【図３】



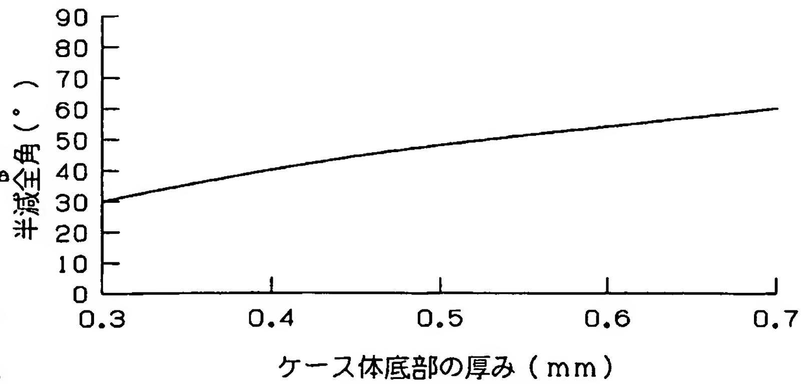
【図４】



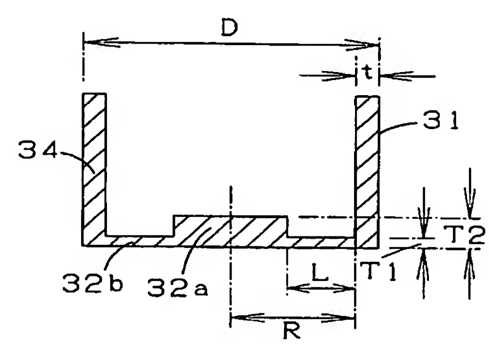
【図５】



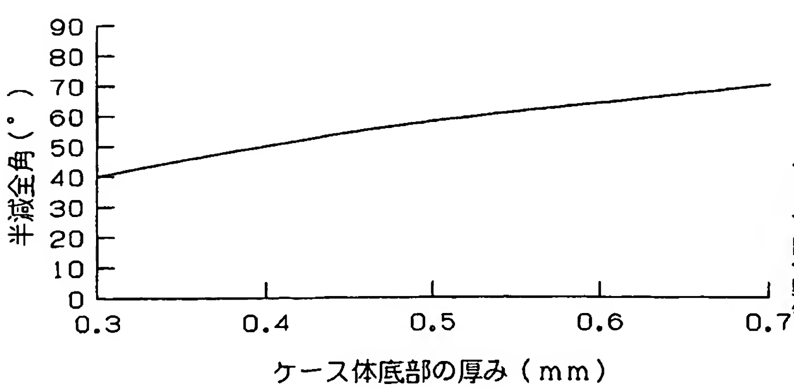
【図６】



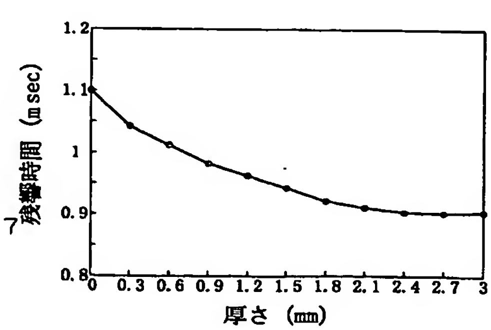
【図８】



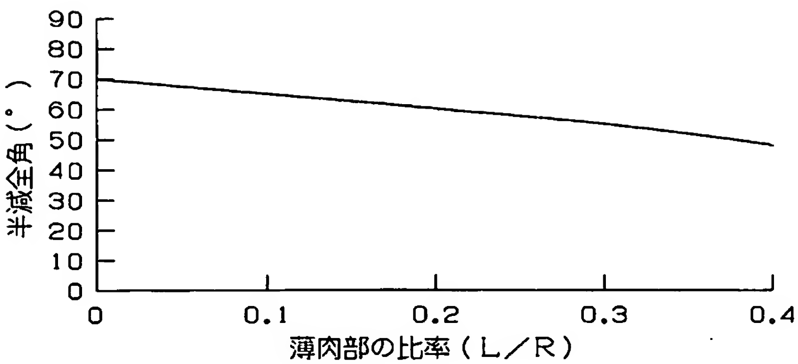
【図７】



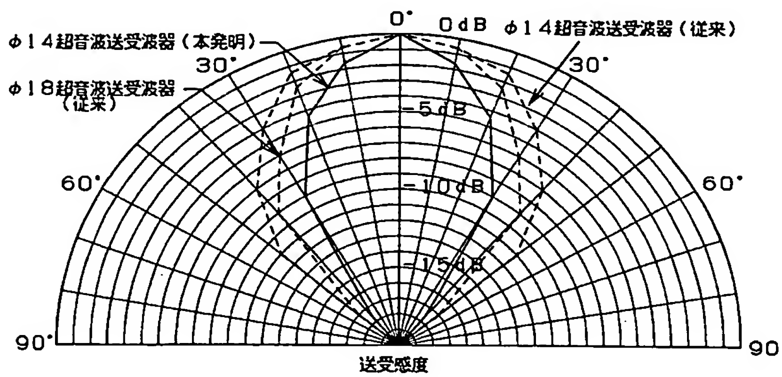
【図１３】



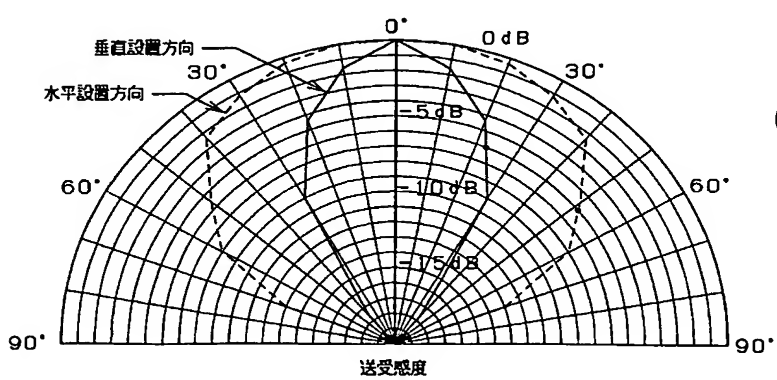
【図９】



【図１０】



【図１１】



【図１２】